Space Weather Aspects of the STEREO Mission

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Introduction

The STEREO Space Weather Group consists of scientists associated with the STEREO teams interested in space weather aspects of the mission. We operate a public web site at http://wwwsolar.nrl.navy.mil/STEREO/swx/swindex.html, where anyone from the scientific community can follow efforts to prepare computer programs, modeling efforts and research studies in preparation to use the STEREO observations as tools for Space Weather. Our activities are coordinated with the STEREO PI Teams and the STEREO Science Center (SSC) at GSFC. *The list of tools and projects below shows the kind of ideas being pursued. We invite scientists from outside the STEREO teams to join in our efforts.* Our group interacts closely with the SECCHI 3D Reconstruction and Visualization Team; some of the 3D tools listed here overlap with science tools being developed by the 3D R&V team: http://wwwsolar.nrl.navy.mil/STEREO/3drv/scisoft/pasadena_replies.pdf.

The STEREO Beacon is the main STEREO effort focused on Space Weather; its main purpose is to provide low resolution, low cadence, near-real-time imaging and in-situ data to NOAA's Space Environment Center (SEC) for forecasting. *The Beacon and its contents are described to the right side of the poster.* In addition to the real-time Beacon data, the full science data stream will be downloaded to the SSC each day. These data will also be important for space weather, both for predicting and in improving our understanding of CME's and related phenomena.

NOAA/SEC is always looking for products which will improve space weather forecasts. STEREO is a mission which has obvious forecasting benefits, but is by no means the only mission. Researchers who have developed tools or methods to improve these products are encouraged to contact NOAA/SEC. *The forecast products which are most needed are shown in the top middle panel.*

NOAA/SEC's BIG LIST

NOAA Space Environment Center forecasting needs.

Highest Priority

- Solar Energetic Particle event forecasts, including start time, end time, peak flux, time of peak flux, spectra, fluence, and probability of occurrence
- Energetic electron flux prediction for International Space Station
- Regional geomagnetic nowcasts and forecasts (e.g., Auroral electrojet maps)
- Ionospheric maps of TEC and scintillation (real-time and future)
- Geomagnetic Indices (A, K, Dst) and Probability forecasts

High Priority

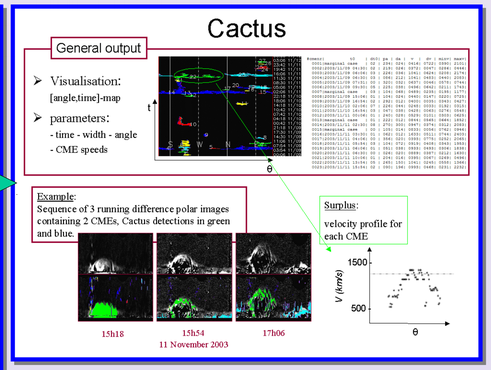
- Geomagnetic activity predictions (1-7 days) based on CME observations, coronal hole observations, solar magnetic observations, and ACE/EPAM observations
- Geomagnetic storm end-time forecast
- Real-time estimates of geomagnetic indices
- Real-time quality diagnostics (verification) of all warning/watch/forecast products
- Routine statistical and/or numerical guidance for all forecast quantities (e.g., climatological forecasts of flares, geomagnetic indices and probabilities, and F10.7—similar to NWS Model Output Statistics)
- Improved image analysis capability (e.g., for SXI, STEREO, SMEI)
- Short-term (days) F10.7 forecasts
- Short-term (days) X-ray flare forecasts
- Magnetopause crossing forecasts based on L1 data
- EUV index

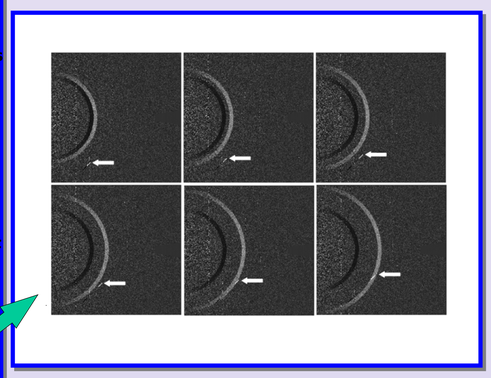
Notes:

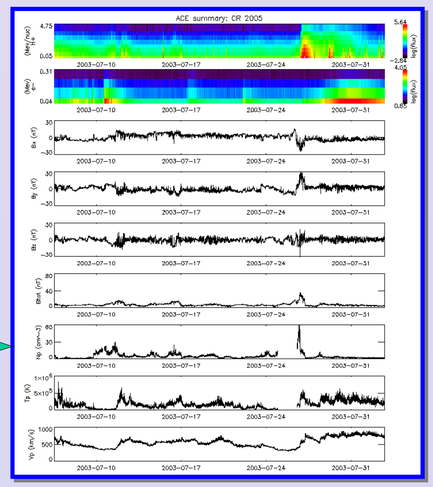
1. Items in each grouping are not necessarily in order
2. Required product lead-time and needed product quality (skill, accuracy, etc.) depend on specific user needs

Tools and Projects Being Developed for STEREO Space Weather Purposes

Title	Leaders/Institutions	Brief Description
GENERAL SCIENCE TOOL		
LOS Tool for SECCHI models. White Light Images	P. Liewer, J. Hall, J. Lorre JPL, NRL	Create synthetic white light images from 3D density data cube. Use with simple CME
AUTOMATED DETECTION and IDENTIFICATION		
Computer Aided CME w/measures of Tracking (CACTus)	E. Robbrecht, D. Berghmans, G. Lawrence, R. van der Linden Royal Observatory Belgium	Near-realtime tool for detecting CMEs in SECCHI images. Outputs: QL CME time, width, speed; NRT CME warnings. Successfully tested on SOHO LASCO CMEs. Test version available at http://sidc.oma.be/cactus.
Computer Aided EUVI EIT images. Wave & Dimming Detection	O. Podladchikova, D. Berghmans, A. Zhukov ROB	NRT tool for detecting EUV waves & dimming regions. To be tested on SOHO
Velocity Map Construction waves; NRT warnings	J. Hochedez, S. Gissot ROB	Program to analyze velocity flows on SECCHI images; detect CME onsets & EUV of fast CMEs; reconstruct 3D velocity maps of CMEs from 2D maps from each STEREO.
Automatic Solar Feature Recognition & Classification in solar & forecast eruptions using filaments & sigmoids.	D. Rust, P. Bernasconi, B. LaBonte, JHU/APL	Tool for detecting and characterizing solar filaments and sigmoids images. Goal is to meas. magnetic helicity parameters
3-D IMAGING TOOLS		
Tie Point Tool location in	E. DeJong, P. Liewer, J. Hall, J. Lorre JPL	Manually create tiepoints between features in SECCHI image pair & solve for 3D heliographic coordinates.
Geometric Localization size and velocity Of STEREO CMEs Earth.	V. Pizzo, D. Biesecker NOAA	Tool utilizing a series of LOSs from two views to define the location, shape, of a CME. To be automated & used to decide whether and when a CME will impact
3D Structure of CMEs configuration & near structure; 3D	V. Bothmer, H. Cremades, D. Tripathi MPI, Ger.	Program to compare analysis of SECCHI images on the internal magnetic field Sun evolution of CMEs with models based on SOHO observations. Forecast flux rope visualization of CMEs.
HELIOSPHERIC STUDIES		
SECCHI HI Beacon mode Earth.	R. Harrison, C. Davis RAL, MSSL	For space weather purposes the prime HI data product is the images sent in the beacon The HIs will observe CMEs along the Sun-Earth line from Cor2 to beyond
Structural Context of reconst. Heliosphere Using observations. SMEI Data	D. Webb, B. Jackson BC/AFRL, UCSD	Assuming an extended SMEI mission, use analyses of SMEI images, including 3D mapping, to provide structural context of the heliosphere for STEREO HI Also provide complementary observations of transient disturbances, especially CMEs.
Identifying & Tracking HIs. Test CMEs with the Helio-measure spheric Imagers	R. Harrison, C. Davis RAL, MSSL	Produce simulations to show that model CMEs can be identified & tracked with the wavelet & other techniques for extracting CME signatures. Use triangulation to speed & direction of CMEs & forecast their Earth arrival.
Interplanetary Acceleration of ICMEs Earth.	M. Owens BU	Construct acceleration profiles of fast ICMEs over a large heliocentric range using multi-point HI observations of the leading edges to understand the forces acting on ICMEs in interplanetary space, & improve predictions of arrival times of ICMEs at
Relationship between CMEs magnetic clouds. and Magnetic Clouds SECCHI	S. Matthews, MSSL	Assess the potential geoeffectiveness of CMEs based their association with What particular characteristics lead to production of a magnetic cloud? Combine images with in-situ measurements from both STEREOs & ACE.
Comparison of WSA provide	N. Arge, J. Luhmann,	The Wang-Sheeley-Arge and ENLIL 3D MHD solar wind models will be integrated to


Cactus
General output
Visualisation: [angle,time]-map
parameters: - time - width - angle - CME speeds
Example: Sequence of 3 running difference polar images containing 2 CMEs, Cactus detections in green and blue.
Surplus: velocity profile for each CME
15h18
15h54
17h06
11 November 2003





Real-time Beacon

The Beacon and Data Flow

633 bps – real-time continuous broadcast (no record capabilities)

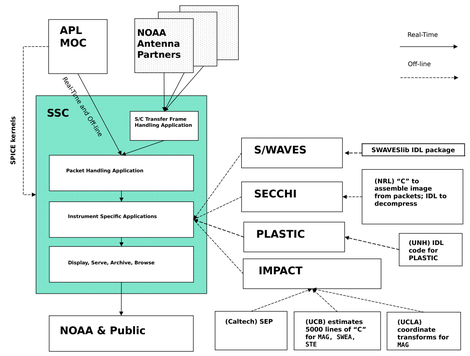


Figure courtesy of W. Thompson

The Beacon Data

IMPACT – numbers in parentheses denote # energy bands

MAG *(Magnetometer)*
***B* vectors at 3 samples/minute**
STE *(Suprathermal Electron Telescope – e* 2–20 keV*)*
***e* flux in 2 look directions, 8 energies, 16 samples/minute**
SWEA *(Solar Wind Electron Analyzer – e* eV–several keV*)*
***e* density, bulk velocity, temperature at 13 samples/minute**
pitch angle distributions at 2 energies, 24 samples/minute
SEPT *(Solar Electron Proton Telescope – e* 20–400keV; *p* 20–7000keV*)*
***e*(2) and *p*(2) flux in 4 look directions (and summed); 1 minute avg.**
LET *(Low Energy Telescope – p* & He 1.5–13 MeV/nuc.; heavy ions 2–30 MeV/nuc.*)*
***p(1)* flux in 2 look directions (and summed); 1 minute avg.**
He(2) flux in 2 look directions; 1 minute avg.
He(1), ^{3}He(2), CNO(3), Fe(4) fluxes; summed over all look angles; 1 minute avg.
HET *(High Energy Telescope – e* <5 MeV; *p* & He <100MeV/nuc.*)*
***e*(1), *p*(3), He(3), CNO(2), Fe(1) fluxes; 1 minute avg.**
SIT *(Suprathermal Ion Telescope* – 30 keV/nuc. – 2 MeV/nuc.*)*
He(4), CNO(4), Fe(4) fluxes; 1 minute avg.

PLASTIC
1 minute resolution
Solar Wind H density, bulk H velocity
Solar Wind H+ temperature and heat flux tensors
Solar Wind He++ peak distribution, position, deflection step, energy step
5 minute resolution
Selected Solar Wind charge states
Suprathermal rates

S/WAVES
1 minute averages; 8 channels/octave from 16 kHz to 16 MHz

SECCHI
7 256x256 pixel images (w/lossy compression) per hour, including:
4 COR2 images
1 HI1/HI2 alternating
+ 4 byte sum of EUVI total intensity; CME detection flag